

**WHAT IS CLAIMED IS:**

1. A three-dimensional structure forming method that forms a three-dimensional structure made of a  
5 photosensitive material on a substrate, said method comprising the steps of:

determining a film thickness of the  
photosensitive material necessary to form the desired  
three-dimensional structure;

10 comparing a predetermined maximum film thickness with the film thickness determined by said determining step; and

applying, when the film thickness determined by said determining step is greater than the  
15 predetermined maximum film thickness, the photosensitive material within the maximum film thickness plural times until the photosensitive material has the film thickness on the substrate.

20 2. A three-dimensional structure forming method according to claim 1, further comprising the steps of:

exposing, with light having an energy distribution corresponding to the desired three-dimensional structure, the photosensitive material  
25 applied by said applying step; and

developing the photosensitive material that has been exposed.

3. A three-dimensional structure forming method according to claim 2, further comprising the step of etching the substrate using the photosensitive material that has been exposed.

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4. A three-dimensional structure forming method according to claim 1, wherein the substrate is an optical element.

10 5. A three-dimensional structure forming method according to claim 1, wherein the substrate is a mold.

6. A three-dimensional structure forming method according to claim 1, wherein the photosensitive  
15 material is made of novolac resin.

7. A three-dimensional structure forming method according to claim 1, wherein said applying step applies the photosensitive material through a solvent,  
20 and the solvent is propylene glycol monomethyl ether acetate.

8. A three-dimensional structure forming method according to claim 1, wherein the maximum film  
25 thickness is equal to or smaller than 12  $\mu\text{m}$ .

9. A three-dimensional structure forming method according to claim 1, wherein the film thickness of the photosensitive material necessary to form the desired three-dimensional structure is equal to or greater than  
5 12  $\mu\text{m}$ .

10. A three-dimensional structure forming method that forms a three-dimensional structure made of a photosensitive material on a substrate, said method  
10 comprising the steps of:

applying onto the substrate photosensitive material with a first film thickness within a preset maximum film thickness; and

applying onto the photosensitive material  
15 with the first film thickness applied onto the substrate, the photosensitive material with a second film thickness within the maximum film thickness.

11. A three-dimensional structure forming method  
20 according to claim 10, further comprising the steps of:

exposing, with light having an energy distribution corresponding to the desired three-dimensional structure, the photosensitive material applied by said applying step; and

25 developing the photosensitive material that has been exposed.

12. A three-dimensional structure forming method according to claim 11, further comprising the step of etching the substrate using the photosensitive material that has been exposed.

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13. A three-dimensional structure forming method according to claim 10, wherein the substrate is an optical element.

10 14. A three-dimensional structure forming method according to claim 10, wherein the substrate is a mold.

15 15. A three-dimensional structure forming method according to claim 10, wherein the photosensitive material is made of novolac resin.

16. A three-dimensional structure forming method according to claim 10, wherein said applying step applies the photosensitive material through a solvent, and the solvent is propylene glycol monomethyl ether acetate.

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17. A three-dimensional structure forming method according to claim 10, wherein the maximum film thickness is equal to or smaller than 12  $\mu\text{m}$ .

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18. A three-dimensional structure forming method  
that forms a three-dimensional structure made of a  
photosensitive material on a substrate, said method  
comprising the steps of repetitively applying and  
5 baking a photosensitive material, and forming the  
photosensitive material with a predetermined thickness  
on the substrate through overlapping applications.

19. A three-dimensional structure forming method  
10 according to claim 18, further comprising the steps of:  
exposing, with light having an energy  
distribution corresponding to the desired three-  
dimensional structure, the photosensitive material  
applied by said applying step; and  
15 developing the photosensitive material that  
has been exposed.

20. A three-dimensional structure forming method  
according to claim 19, further comprising the step of  
20 etching the substrate using the photosensitive material  
that has been exposed.

21. A three-dimensional structure forming method  
according to claim 18, wherein the substrate is an  
25 optical element.

22. A three-dimensional structure forming method according to claim 18, wherein the substrate is a mold.

23. A three-dimensional structure forming method  
5 according to claim 18, wherein the photosensitive material is made of novolac resin.

24. A three-dimensional structure forming method according to claim 18, wherein said applying step  
10 applies the photosensitive material through a solvent, and the solvent is propylene glycol monomethyl ether acetate.

25. An optical element manufactured by a three-  
15 dimensional structure forming method that forms a three-dimensional structure made of a photosensitive material on a substrate, said method comprising the steps of determining a film thickness of the photosensitive material necessary to form the desired  
20 three-dimensional structure, comparing a predetermined maximum film thickness with the film thickness determined by said determining step, and applying, when the film thickness determined by said determining step is greater than the predetermined maximum film  
25 thickness, the photosensitive material within the maximum film thickness plural times until the

photosensitive material has the film thickness on the substrate.

26. An optical element according to claim 25,  
5 wherein the optical element is a lens array that forms plural lenses on an array.

27. An optical element according to claim 26,  
wherein the plural lenses have a shape of a hexagon, an  
10 arc, or a rectangle.

28. An optical element according to claim 27,  
wherein the shape has a width between 12  $\mu\text{m}$  and 2 mm.

15 29. An optical element manufactured by a three-dimensional structure forming method that forms a three-dimensional structure made of a photosensitive material on a substrate, said method comprising the steps of applying onto the substrate photosensitive  
20 material with a first film thickness within a preset maximum film thickness, and applying onto the photosensitive material with the first film thickness applied onto the substrate, the photosensitive material with a second film thickness within the maximum film  
25 thickness.

30. An optical element according to claim 29,  
wherein the optical element is a lens array that forms  
plural lenses on an array.

5           31. An optical element according to claim 30,  
wherein the plural lenses have a shape of a hexagon, an  
arc, or a rectangle.

32. An optical element according to claim 31,  
10 wherein the shape has a width between 12  $\mu\text{m}$  and 2 mm.

33. An optical element manufactured by a three-  
dimensional structure forming method that forms a  
three-dimensional structure made of a photosensitive  
15 material on a substrate, said method comprising the  
steps of repetitively applying and baking a  
photosensitive material, and forming the photosensitive  
material with a predetermined thickness on the  
substrate through overlapping applications.

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34. An optical element according to claim 33,  
wherein the optical element is a lens array that forms  
plural lenses on an array.

25           35. An optical element according to claim 34,  
wherein the plural lenses have a shape of a hexagon, an  
arc, or a rectangle.



36. An optical element according to claim 35,  
wherein the shape has a width between 12  $\mu\text{m}$  and 2 mm.

37. A biochip manufactured by a three-dimensional  
5 structure forming method that forms a three-dimensional  
structure made of a photosensitive material on a  
substrate, said method comprising the steps of  
determining a film thickness of the photosensitive  
material necessary to form the desired three-  
10 dimensional structure, comparing a predetermined  
maximum film thickness with the film thickness  
determined by said determining step, and applying, when  
the film thickness determined by said determining step  
is greater than the predetermined maximum film  
15 thickness, the photosensitive material within the  
maximum film thickness plural times until the  
photosensitive material has the film thickness on the  
substrate.

20 38. A biochip manufactured by a three-dimensional  
structure forming method that forms a three-dimensional  
structure made of a photosensitive material on a  
substrate, said method comprising the steps of applying  
onto the substrate photosensitive material with a first  
25 film thickness within a preset maximum film thickness;  
and applying onto the photosensitive material with the  
first film thickness applied onto the substrate, the

photosensitive material with a second film thickness within the maximum film thickness.

39. A biochip manufactured by a three-dimensional  
5 structure forming method that forms a three-dimensional  
structure made of a photosensitive material on a  
substrate, said method comprising the steps of  
repetitively applying and baking a photosensitive  
material, and forming the photosensitive material with  
10 a predetermined thickness on the substrate through  
overlapping applications.

40. An optical system comprising the optical  
element manufactured by a three-dimensional structure  
15 forming method that forms a three-dimensional structure  
made of a photosensitive material on a substrate, said  
method comprising the steps of determining a film  
thickness of the photosensitive material necessary to  
form the desired three-dimensional structure, comparing  
20 a predetermined maximum film thickness with the film  
thickness determined by said determining step, and  
applying, when the film thickness determined by said  
determining step is greater than the predetermined  
maximum film thickness, the photosensitive material  
25 within the maximum film thickness plural times until  
the photosensitive material has the film thickness on  
the substrate.

41. An optical system comprising the optical element manufactured by a three-dimensional structure forming method that forms a three-dimensional structure made of a photosensitive material on a substrate, said  
5 method comprising the steps of applying onto the substrate photosensitive material with a first film thickness within a preset maximum film thickness, and applying onto the photosensitive material with the first film thickness applied onto the substrate, the  
10 photosensitive material with a second film thickness within the maximum film thickness.

42. An optical system comprising the optical element manufactured by a three-dimensional structure  
15 forming method that forms a three-dimensional structure made of a photosensitive material on a substrate, said method comprising the steps of repetitively applying and baking a photosensitive material, and forming the photosensitive material with a predetermined thickness  
20 on the substrate through overlapping applications.

43. An exposure apparatus comprising an optical system and exposes an object through the optical system,  
wherein said optical system includes the  
25 optical element manufactured by a three-dimensional structure forming method that forms a three-dimensional structure made of a photosensitive material on a

substrate, said method comprising the steps of  
determining a film thickness of the photosensitive  
material necessary to form the desired three-  
dimensional structure, comparing a predetermined  
5 maximum film thickness with the film thickness  
determined by said determining step, and applying, when  
the film thickness determined by said determining step  
is greater than the predetermined maximum film  
thickness, the photosensitive material within the  
10 maximum film thickness plural times until the  
photosensitive material has the film thickness on the  
substrate.

44. An exposure apparatus comprising an optical  
15 system and exposes an object through the optical system,  
wherein said optical system includes the  
optical element manufactured by a three-dimensional  
structure forming method that forms a three-dimensional  
structure made of a photosensitive material on a  
20 substrate, said method comprising the steps of applying  
onto the substrate photosensitive material with a first  
film thickness within a preset maximum film thickness,  
and applying onto the photosensitive material with the  
first film thickness applied onto the substrate, the  
25 photosensitive material with a second film thickness  
within the maximum film thickness.

45. An exposure apparatus comprising an optical system and exposes an object through the optical system, wherein said optical system includes the optical element manufactured by a three-dimensional structure forming method that forms a three-dimensional structure made of a photosensitive material on a substrate, said method comprising the steps of repetitively applying and baking a photosensitive material, and forming the photosensitive material with a predetermined thickness on the substrate through overlapping applications.

46. A device fabrication method comprising the steps of:

15 exposing an object using an exposure apparatus; and

developing the object that has been exposed, wherein said exposure apparatus includes an optical system and exposes an object through the optical system, and

20 wherein said optical system includes the optical element manufactured by a three-dimensional structure forming method that forms a three-dimensional structure made of a photosensitive material on a substrate, said method comprising the steps of

25 determining a film thickness of the photosensitive material necessary to form the desired three-

dimensional structure, comparing a predetermined maximum film thickness with the film thickness determined by said determining step, and applying, when the film thickness determined by said determining step is greater than the predetermined maximum film thickness, the photosensitive material within the maximum film thickness plural times until the photosensitive material has the film thickness on the substrate.

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47. A device fabrication method comprising the steps of:

exposing an object using the exposure apparatus; and

15                developing the object that has been exposed, wherein said exposure apparatus includes an optical system and exposes an object through the optical system, and

                 wherein said optical system includes the  
20 optical element manufactured by a three-dimensional structure forming method that forms a three-dimensional structure made of a photosensitive material on a substrate, said method comprising the steps of applying onto the substrate photosensitive material with a first  
25 film thickness within a preset maximum film thickness, and applying onto the photosensitive material with the first film thickness applied onto the substrate, the

photosensitive material with a second film thickness within the maximum film thickness.

48. A device fabrication method comprising the  
5 steps of:

exposing an object using the exposure  
apparatus; and

developing the object that has been exposed,  
wherein said exposure apparatus includes an  
10 optical system and exposes an object through the  
optical system, and

wherein said optical system includes the  
optical element manufactured by a three-dimensional  
structure forming method that forms a three-dimensional  
15 structure made of a photosensitive material on a  
substrate, said method comprising the steps of  
repetitively applying and baking a photosensitive  
material, and forming the photosensitive material with  
a predetermined thickness on the substrate through  
20 overlapping applications.